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SIGNIFICANT VECTOR PROBLEMS IN THE SOUTH PLATTE RIVER BASIN

Public Health Service
Denver, Colorado

March 1965

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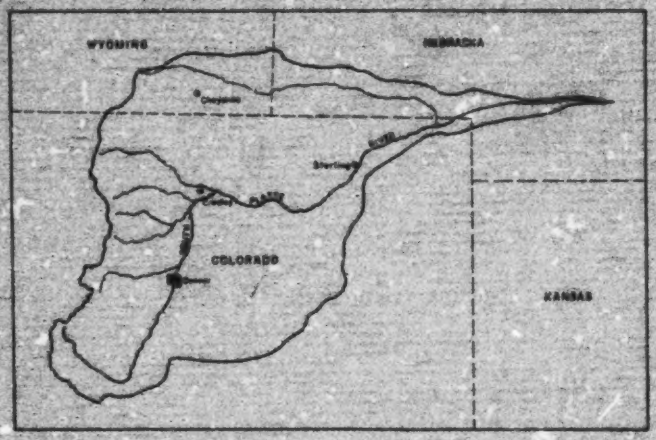

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PUBLIC HEALTH SERVICE, REGION VIII
DENVER, COLORADO

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U. S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
Public Health Service
Region VIII
Denver, Colorado

March 1965

Division of Water Supply and Pollution Control
South Platte River Basin Project
Denver, Colorado
and
Communicable Disease Center
Disease Ecology Section
Greeley, Colorado

I

SOUTH PLATTE RIVER BASIN PROJECT
U. S. Public Health Service

Background and Objectives

On July 18, 1963, the Governor of Colorado requested the Secretary of Health, Education, and Welfare to assist the State in determining sources of pollution and quality of waters of the South Platte River Basin within the State of Colorado.

The First Session of the Conference in the matter of Pollution of the South Platte River Basin was held in Denver, Colorado, on October 29, 1963, under the provisions of the Federal Water Pollution Control Act as amended (33 U.S.C. 466g). It was established at this Conference that a study would be undertaken by facilities of the U. S. Public Health Service. Findings and recommendations from this study would lead to a program of pollution abatement to be developed jointly by the South Platte River Basin Project, Public Health Service, and the Colorado State Department of Public Health.

The long-range goals and objectives of the Project are as follows:

1. Determine the legitimate water uses and locate the sources of pollution having an adverse effect on those uses.

2. Through field investigations determine the physical, chemical, and biological responses of the River to pollution and evaluate the previously located sources of pollution with respect to the conditions in the River.

3. Compute the waste load reductions necessary to obtain desired water quality and recommend water quality control measures needed to effect the desired waste load reductions.

Organization

The South Platte River Basin Project consists of engineering and associated professional and clerical personnel. The Project Headquarters offices are located in downtown Denver and the Laboratory has been established at the Colorado State Department of Public Health, Denver, Colorado. The Project is administratively attached to the Water Supply and Pollution Control program of the Public Health Service, U. S. Department of Health, Education, and Welfare, Region VIII, Denver, Colorado.

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Denver, Colorado

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Denver, Colorado

Tri-County District Health Department
Adams City, Colorado

U. S. Department of Health, Education, and Welfare
Region VIII, Public Health Service
Communicable Disease Control Services
Denver, Colorado

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SUMMARY AND CONCLUSIONS

Essentially the vector problems within the Basin involve mosquitoes, rats, and flies. Flies occur widely throughout the Basin and transmit a wide range of enteric diseases. Certain serious diseases are transmitted by mosquitoes and rat fleas (i.e., encephalitis and plague, respectively), and are of considerable public health significance. Aside from their disease-causing potential, mosquitoes, rats, and flies are responsible for substantial economic losses and require considerable expenditures for their elimination and control.

Ideal mosquito breeding grounds exist throughout the Basin. Improper irrigation practices create many seeps and standing pools of water in which mosquitoes breed readily. In addition, the many sloughs and backwaters along the river bottoms provide ideal areas for mosquito production. The presence of heavy organic pollution from sewage and industrial wastes in many of these waters enhances the environment for excessive production of those species of mosquitoes associated with the transmission of encephalitis. Encephalitis has occurred sporadically in the Basin with the most recent outbreaks of note occurring in 1957 and 1964.

Certain areas within the Basin have serious rat infestation problems. The most notable of these is the concentration of a large rat population along the banks of the South Platte River and its tributaries in the northern sector of Metropolitan Denver. Rats are actually semi-aquatic by nature and adapt readily to life along river banks, particularly where brush and trash along the banks provide good cover and harborage. In this case, an excellent food supply is readily available from the heavy load of floating organic pollution present in the South Platte River and its tributaries. The presence of this highly concentrated rat population constitutes a potential plague threat to area citizens.

Several species of biting and non-biting gnats and black flies breed extensively in the waters of the Basin. These insects cause severe human annoyance and occasionally are involved in disease transmission. The presence of organic pollution in the breeding waters creates a favorable larval environment and results in increased production of these insects. The most serious house fly problems in the Basin stem from the extensive breeding of flies in the accumulated manure piles associated with cattle feedlots and stockyards and in the garbage spread for the feeding of hogs at various hog farms. These substances all provide the type of warm, moist, organic environment required for fly larvae development. Many of these farms and feedlots are in close proximity to Basin streams.

Significant vector populations of mosquitoes, rats, and flies exist in the Basin and constitute a serious public health hazard. These vectors, especially mosquitoes and rats, are directly associated with the organic pollution present in the waters of the Basin. This pollution is instrumental in creating and supporting the present high population levels of disease-carrying vectors, particularly in the Denver Metropolitan area.

Future vector population levels will remain high as long as significant quantities of organic pollutants are discharged to the waters of the Basin. Reduction or elimination of present vector populations will best be accomplished through the abatement or elimination of the gross organic pollution now being discharged to receiving waters throughout the Basin.

INTRODUCTION

The objectives of this study were to determine the nature and extent of the significant disease vector problems within the South Platte River Basin and to evaluate the effect of water pollution on vector population levels.

The South Platte River drainage encompasses 24,300 square miles, of which 19,450 is in the State of Colorado and 2,050 and 2,800 square miles respectively, in the States of Wyoming and Nebraska. The South Platte River originates on the east side of the Continental Divide in central Colorado, flows northeast across the State, and joins the North Platte River at North Platte, Nebraska. Principal tributaries of the South Platte River are Bear Creek, Cherry Creek, Clear Creek, St. Vrain Creek, Big Thompson River, Cache la Poudre River, Crow Creek, and Lodgepole Creek. A general map of the South Platte River Basin is given in Figure 1, following page 22.

Surface water resources in the Basin have been greatly over-appropriated for irrigation use. In summer, very low flows occur at many points on Basin streams where agricultural diversions may use all, or nearly all, of the available streamflow.

The 1960 population of the Basin was approximately 1,210,000 persons, of which 92 percent was in the State of Colorado, and four percent each in Wyoming and Nebraska. The population has increased at a very rapid rate. From 1940 to 1950 the population increased from 660,000 to 840,000 with an estimate for 1964 of 1,410,000. (1)

The population growth of the Denver Metropolitan area has been particularly remarkable with an increase from 1950 to 1960 of 499,000 to 804,000, and a further rise to approximately 1,000,000 persons as of 1964. The Denver Metropolitan area contains about 70 percent of the total Basin population and is an extremely important manufacturing and trade center for a large part of the Rocky Mountain Region. Other centers of population in the Basin as of 1964 include Boulder, 46,000; Fort Collins, 30,400; and Greeley, Colorado, 31,600; as well as Cheyenne, Wyoming, 52,000. (1)

The approach used in respect to this evaluation was to review those reports on file at the Disease Ecology Section, Communicable Disease Center, Greeley, Colorado, which dealt with the vector studies conducted by CDC and other health agencies within the Basin. Also, a mosquito survey and other field observations were made within the Denver area by South Platte River Basin Project and CDC personnel during the summer of 1964. The above information, supplemented by information of a general nature, has been used to present an overall picture of the present-day vector problems within the Basin.

GENERAL DISCUSSION

Mosquitoes

Mosquitoes are the vectors of principal public health significance in the Basin. Several species of public health and socio-economic importance are produced in large numbers in areas where environmental conditions are favorable.

Viral encephalitis, commonly known as sleeping sickness or brain fever, is now the most important mosquito-borne disease in the United States and in the South Platte River Basin. This should not be confused with the dread African sleeping sickness (Trypanosomiasis) which is transmitted by the tsetse fly and caused by a microscopic parasitic protozoan.

The reservoir for viral encephalitis is thought to be the blood of wild birds and domestic poultry. Mosquitoes obtain the virus by feeding on infected birds and transmit it to horses and humans while obtaining subsequent blood meals, as shown in Figures 2a and 2b. There are no effective chemotherapeutic measures for the prevention of or treatment of human cases and some individuals, particularly children who recover from the disease, often suffer permanent mental disability.

Three types of viral encephalitis are commonly recognized in the United States: Eastern Equine Encephalitis (EEE), Western Equine Encephalitis (WEE), and St. Louis Encephalitis (SLE). The geographical distribution of the three virus types is given in Figure 3. Both EEE and WEE produce clinical disease in man and horse alike, while SLE produces clinical disease in man only. Of the three virus strains, WEE and SLE are endemic to the Basin. Encephalitis has occurred in horses throughout the Basin for the period of record dating back to 1939. Human cases have occurred sporadically and intermittently with the more recent outbreaks of note occurring in 1957 when over 100 cases were reported, and in 1964 when 30 were reported, including three fatalities.

Members of the genus Culex are the most significant mosquitoes in the transmission of encephalitis in the Basin. Entomological investigations have shown that these mosquitoes occur in great numbers throughout the Basin and have considerable impact as a nuisance problem aside from their disease-carrying potential.

Culex tarsalis is the single most important vector of encephalitis for man and horses in the Basin. The mosquito feeds readily on birds, horses, and man, with some preference indicated for birds. An interesting explanation for the C. tarsalis-bird association is given as follows:

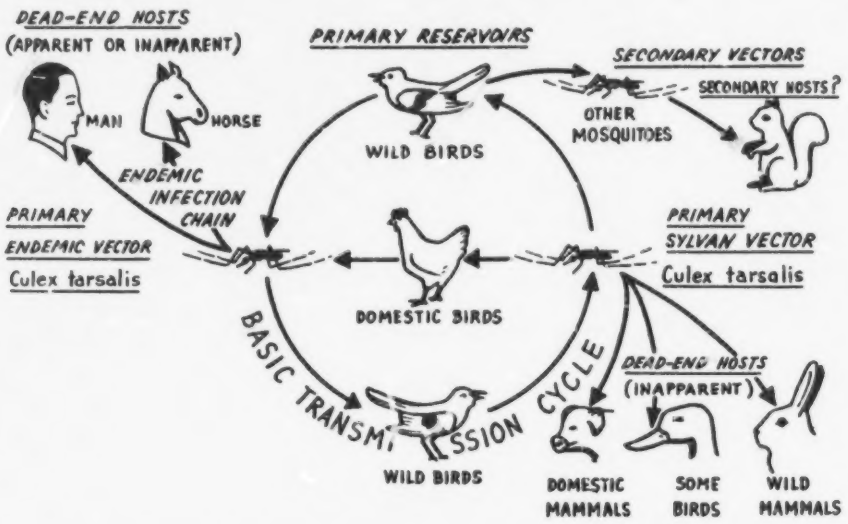

Figure 2a: Summer infection chains for western equine encephalitis. (The chains for rural St. Louis encephalitis are similar except that horses are inapparent rather than apparent hosts.) Hess and Holden, 1958.

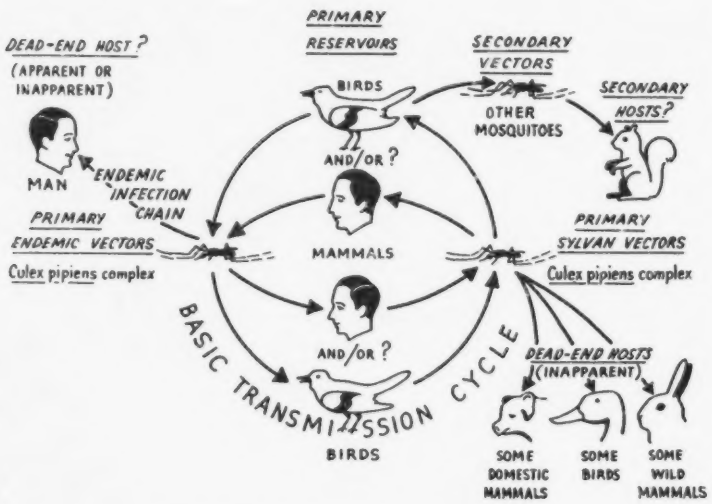

Figure 2b: Summer infection chains for urban St. Louis encephalitis (chains for rural SLE are similar to those for WEE). Hess and Holden, 1958.

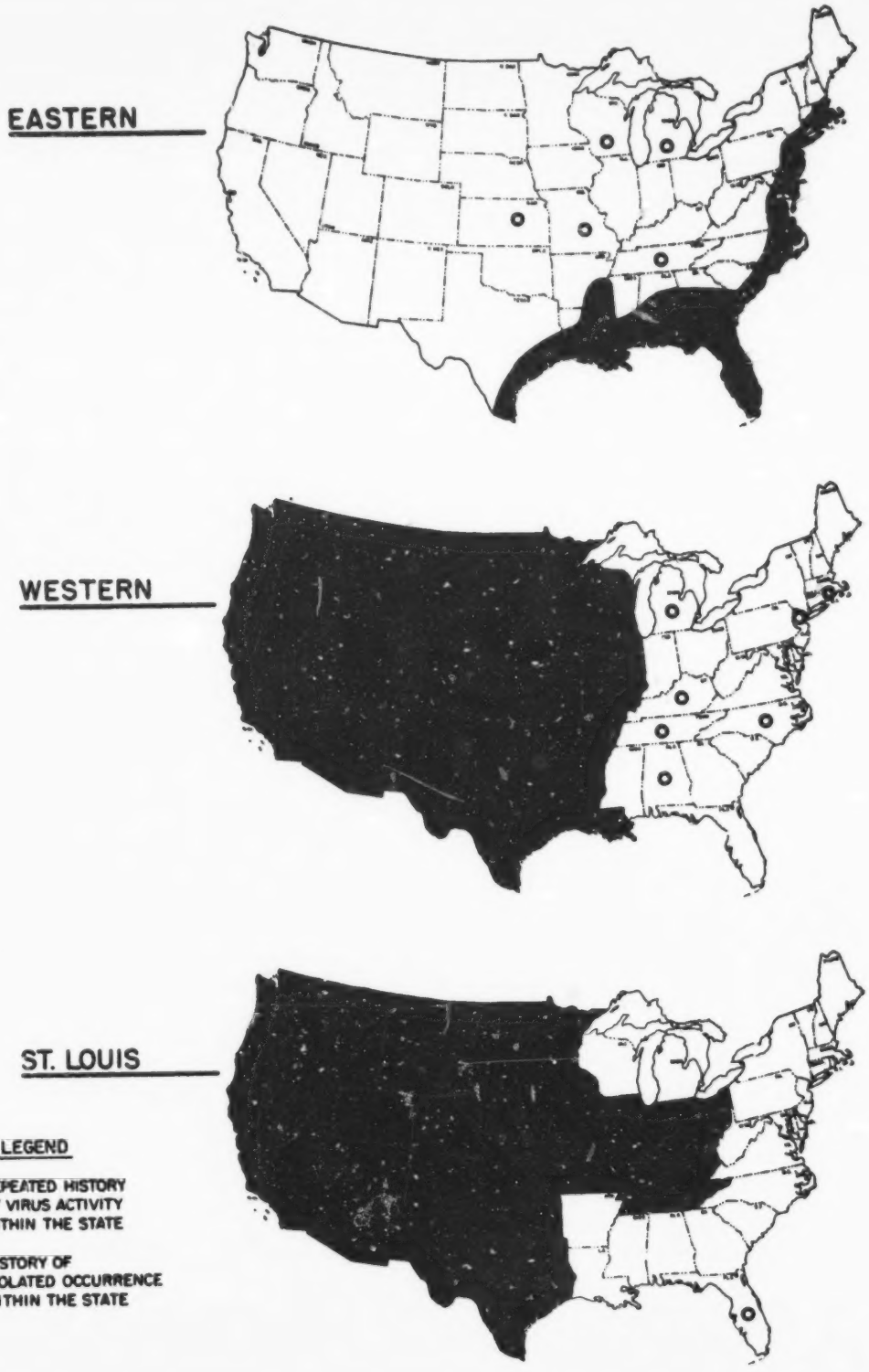

Figure 3. The geographical distribution of the arthropod-borne encephalitides in the United States. Total virus activity in man and in animals. Hess and Holden, 1958.

Many birds nest in trees, going to roost about dusk, which coincides with the most active feeding period for C. tarsalis. The foilage of the trees gives off an excess of carbon dioxide at night when photosynthesis has ceased. C. tarsalis is attracted by carbon dioxide and is brought into the sphere of the roosting birds at the time when it is most active in seeking a blood meal. (2) Since birds also act as the reservoir for the encephalitis virus, all the elements for transmission of the disease are brought together in time and space.

C. tarsalis larvae develop in a wide variety of aquatic environments, and are frequently found in waste water associated with improper irrigation practices. They also breed in artificial containers and structures including cesspools. Waters containing large quantities of organic matter from human wastes are often preferred. Dispersion studies have shown that adult C. tarsalis will fly as far as ten miles, but the majority of individuals probably remain within one mile of the original larval habitat. (3)

Culex pipiens and Culex quinquefasciatus are of importance in the transmission of urban SLE in human populations, particularly in the Midwest. Within the Basin, C. pipiens and Culiseta inornata are considered to be of particular significance in the transmission cycle of encephalitis among bird and wild mammal hosts, respectively. C. pipiens and C. quinquefastiatus breed profusely in practically all types of artificial containers and in polluted ground pools, cesspools, open septic tanks, and effluent drains from sewage treatment plants. (2) C. pipiens in particular is often associated with grossly polluted water and will breed readily even in undiluted sewage.

The presence of ideal breeding sites and mosquito problem areas within the Basin is well documented by various reports on file at CDC, Greeley, and by field observations by CDC and South Platte River Basin Project personnel. In addition, field studies conducted during the summer of 1964 indicate extensive production of C. tarsalis and C. pipiens in the sewage-laden waters northeast of Denver.

The mosquito vectors of encephalitis would undoubtedly be present to some degree in the Basin even if no water pollution were present. However, the presence of organic pollution from sewage and industrial wastes in certain of the waters, particularly the South Platte River, leads to increased production of these vector mosquitoes. Not only is the water enriched in terms of larval food supply, but existing predator populations are generally intolerant of this pollution. The resulting increase in adult mosquito populations often creates increased competition for the available supply of blood meals. The mosquitoes then range more freely in search of food, thus increasing the possibility of contacting a bird or mammal infected with encephalitus virus and subsequently transmitting the disease to man.

A close scrutiny of the Basin topography helps to explain why encephalitis is common within the South Platte River Basin. A great portion of the area consists of rolling plains cut by meandering streams which create uncounted backwaters and sloughs along their bottoms. As previously explained, the presence of organic pollution in many of these waters enhances the production of vector mosquitoes. Climate and topography limit the only significant concentrations of trees in the Basin to the stream bottom land. As birds generally require trees for roosting and nesting, a large avian population is concentrated along the stream bottoms. These conditions establish an ideal environment for the perpetuation of both host and vector populations.

Several species of the vicious-biting Aedes mosquito occur in the Basin area. These species are produced in great numbers in temporary surface pools associated with irrigation and in ponds or reservoirs having shallow, vegetated areas subject to fluctuating water levels. Overflow pools along streams also provide favorable larval habitats for these highly pestiferous mosquitoes. Concentrations of these mosquitoes may create public health problems by interfering with the normal outdoor activities of both children and adults during the summer months. Children frequently require medical attention and even hospitalization for treatment of secondary infections and allergic reactions from mosquito bites. In addition to their public health importance, large numbers of biting mosquitoes also cause severe economic losses by reducing the efficiency of agricultural and industrial workers; by reducing the vitality of farm animals and thereby lowering meat and dairy production; by interfering with outdoor recreation and entertainment; and by lowering real estate values. In the form of more tangible losses, considerable expenditures are made each year by municipalities and individuals for chemical controls and screening to provide partial protection from mosquitoes.

Domestic Rats

While the South Platte River Basin provides a suitable environment for several wild rodent species, the rodent of greatest public health significance is Rattus norvegicus, the Norway Rat. Because of its strict dependence on man, this rodent, although essentially wild in nature, has come to be known as the domestic rat. Domestic rats are reservoirs or vectors of several diseases, among which are murine typhus fever, plague, salmonellosis, hemorrhagic jaundice or Weil's Disease, rat-bite fever, and trichinosis. (4) Of these, plague, which is endemic to the Basin, is of greatest significance to this area because of the nearly always fatal nature of the disease and the public health controls required when outbreaks occur in local rodent populations.

Plague, the "Black Death" which once was responsible for millions of deaths in Europe, Asia, and Africa, and which has occurred in the coastal cities of the United States, is an acute infection running a rapid, severe course. There have been no serious outbreaks in the United States since 1924, although five cases have occurred in the Western United States since 1956, three terminating fatally. (5)

A plague reservoir exists in the blood of many of the wild rodents of the Western United States. The disease may be transmitted from wild rodent to domestic rat to man by the bite of parasitic fleas associated with these rodents. The disease is usually fatal to the rodents and fleas as well as man. Contact between rats and other rodents most frequently occurs in the area of a common food supply such as an open dump, or along waterways, particularly those polluted with organic solids. During such contact the parasitic fleas often change hosts, thereby transmitting the disease from rodent to rodent.

It is generally accepted that rats will readily infest such areas as open dumps, produce markets, farms, and stockyards, etc. Rats will just as readily infest the banks of a stream if the stream is carrying a heavy load of organic solids which will serve as a food supply. Rats require water daily and if, as in the case of most polluted streams, they can obtain both food and water from the same source, they are more than willing. They can usually find excellent cover and harborage among the jumble of rock and brush found along most stream banks. In essence, the stream is furnishing the rats with three of the basic requirements for life--water, food, and shelter.

The fact that rats are semi-aquatic by nature and will readily "swim for their supper" is well documented by the following passage from a report by Cottam. (6)

> "An example of the Norway rat's adaptability was recently brought to my attention at the U. S. Fish Hatchery Station at Leetown, West Virginia. Despite the fact that several buildings and food storage bins are kept reasonably free of rats from 50 to 200 yards distant, a surprisingly large colony was found living in earthen banks adjacent to the fish ponds and stream courses where concentrations of fish are kept. The spawn, fingerlings, and adult fish--primarily of species or varieties of trout and bass--are fed horse meat daily as well as other prepared foods that are equally acceptable to the rat colony. Undoubtedly bits of food accidentally dropped on the bank in feeding operations accustom the rats to that type of diet. It is obvious that an inadequate food supply occurs on the land, and the rats have learned to obtain it from the water. In their competition for food, the young and small fish at all hatcheries concentrate in enormous numbers when food is thrown into the water. Consequently,

food is available for a very short period only. The rats as well as the fish have learned this. Therefore, at this hatchery these normally nocturnal rats have synchronized their feeding time to correspond with the feeding of the fish. When food is thrown into the water, the rats have no hesitancy in competing for it. They swim well and rapidly. After the food in the water is consumed, they then seek tidbits inadvertently dropped on the bank.

"Apparently low temperature is no serious deterrent to the rat's aquatic activity. On the day of my visit, December 10, 1947, the temperature was considerably below freezing, and an unpleasant sleet and snow storm was in progress; even so, a dozen rats were observed in the water, and part of their runway extended through small areas of the stream. While omnivorous rats avidly consume all kinds of fish food, it was a surprise to find that they are not at all averse to preying on young fish. On a number of occasions the rats have been observed catching the fingerling fish and taking them into their ditchbank runways or burrows."

Identical observations have been made at the White Trout farm at Paradise, Utah, by personnel of the Logan Field Station, CDC, Logan, Utah.

Unfortunately, the overall rat problem throughout the South Platte Basin is not well documented. Problem areas have been reported in the vicinity of Boulder, Longmont, Fort Morgan, and Brush, as well as Denver. Current information is available on the Denver area and there is no question as to the problem itself or as to the association of rats with pollution in the South Platte River. Rat infestation is extremely heavy along the South Platte River and the Burlington-O'Brian Canal in the Northern Metropolitan area. A rat eradication program conducted by the City and County of Denver during 1963 in this area has done much to improve the situation. However, a significant rat population still remains, particularly in adjacent Adams County. The problem is further compounded by the easy paths of migration available to the rats for reaching the heart of the city itself. Should plague appear in the rat population along the river, it might then be easily and rapidly spread throughout the Metropolitan area. Although Denver is the only area to be documented by current observation, it is also the site of the greatest population concentration within the Basin. Furthermore, on the basis of the published literature available and observations by CDC, Greeley and the Denver City and County Health Department, one can logically expect to find medium to heavy rat infestation along the banks of the Basin's streams wherever widespread organic pollution exists.

Flies and Miscellaneous Vectors

While several species of flies are present within the Basin, including some biting flies, the one of greatest public health significance is the common house fly, Musca domestica. The house fly is important because of its ability to transmit disease-causing organisms. Flies carry these organisms in five ways: 1) on their mouth parts, 2) in their vomitus, 3) on their leg and body hairs, 4) on the sticky pads of their feet, and 5) through the intestinal tract by means of fly feces. Diseases transmitted in such manner include typhoid, paratyphoid, cholera, bacillary dysentery, infantile diarrhea, amoebic dysentery, pinworm, roundworm, whipworm, hookworm, tapeworm, anthrax, and tularemia. (7)

The life cycle of the house fly begins with the egg and goes progressively through three larval stages to the pupae and finally to the adult. In rural areas the most common breeding medium is manure, although almost any warm, moist, organic material is used. Unprotected garbage is usually the source of most house fly problems in urban areas. Within the Basin a serious house fly problem does exist in the manure piles adjacent to many of the cattle feedlots and at hog farms where garbage is fed to the hogs. Many of these feedlots and hog farms are closely associated with Basin streams. House fly breeding is also associated with many areas along the Basin stream bottoms where the soil is heavily contaminated with sewage and industrial wastes carried by the streams. In the Denver area, very extensive house fly breeding occurs in the sludge-drying beds at the Denver Northside Sewage Treatment Plant.

Several groups of insects may be produced in sufficient numbers in aquatic habitats to create public health and economic problems. Deer flies and horse flies (Tabanidae) are produced along the margins of impoundments and in marshy seeps. These insects are vicious biters of both man and livestock and are sometimes involved in the transmission of diseases such as tularemia and anthrax. Some species of small gnats (no-see-ums) of the family Heleidae (=Ceratopogonidae) are also vicious biters and often cause severe reactions and vesicular lesions. In certain areas, black flies (Simulidae) plague both men and livestock with their irritating and painful bites and large swarms of these flies can kill an animal rapidly. (6) The small, non-biting midges (Tendipedidae) and the phanton midges (Chaoborinae) are another group of pestiferous insects which may be produced in both flowing and impounded waters. These insects are attracted to lights in tremendous numbers and may cause severe human annoyance.

Thriving populations of the above groups of gnats, black flies and midges are produced in moderately-polluted water where they feed on suspended microscopic organics. Waters enriched by organic pollution may produce excessive algal mats which support abundant populations of many genera.

One family of flies, Syrphidae, variously known as Hover, Flower, and Bee flies breeds in sewage and is the adult form of the rat-tailed maggot. Such flies are primarily a nuisance organism, but members of the genera Tubifera and Helophilus may cause human intestinal myiasis. (7)

Terrestial arthropods of public health significance include ticks, mites, and fleas. These are often vectors of several human diseases, including Rocky Mountain spotted fever, Colorado tick fever, tularemia, relapsing fever, tick paralysis, typhus, typhoid, and bacillary dysentery. In addition, the bites of these arthropods cause considerable irritation, discomfort and annoyance. Little association is known between these vectors and water pollution, except as they occur as parasitic forms on rats associated with pollution.

FIELD INVESTIGATIONS - 1964

Mosquito Production in the North Denver-Barr Lake Area During the 1964 Season

A field study was conducted during the summer of 1964 to determine what species of mosquitoes, if any, were breeding in the sewage-laden surface waters northeast of Denver. A map of the study area is given in Figure 4.

Fourteen larval sampling stations were selected in the Barr Lake area. Stations 1 through 7 were situated on the lake itself. The remaining seven stations were situated in a four-mile radius from the lake. All sampling was done in polluted water except for Station 12, which was fresh water seepage.

Five larval sampling stations, numbers 15-19, were set up in North Denver, principally at seepage areas along Sand Creek and Clear Creek. These two tributaries of the South Platte River are both heavily loaded with organic pollution from sewage and industrial wastes.

Larvae were collected from their natural habitat with a one-pint dipper. They were then placed in water-tight containers and taken to the CDC laboratory at Greeley where they were killed, identified, recorded, and preserved.

A New Jersey type light trap was set up and operated at both the North Denver and Barr Lake areas. Each trap was equipped with a killing jar partially filled with potassium cyanide pellets, which killed the adults shortly after collection. Specimens from the traps were sorted, identified, and recorded at CDC, Greeley.

Larval collection stations were sampled at weekly intervals from May through mid-August and then at bi-weekly intervals through September 4. Light trap collections were made twice weekly at the two stations through mid-August and then at weekly intervals through September 4.

The species of mosquito larvae collected during each month and the percentage composition of each species are shown in Table I. A total of 993 larvae, representing five species of mosquitoes, was collected from the representative mosquito-producing habitats during the study. Aedes vexans and Aedes dorsalis were the dominant species during the month of May, comprising 61 percent of the specimens collected. Culiseta inornata and Culex tarsalis comprised 21 percent and 17 percent of the specimens, respectively.

From June through the remainder of the study, C. tarsalis, C. pipiens, and C. inornata comprised 83 percent of the total mosquito production in the study area. C. tarsalis and C. pipiens are both primary vectors in the transmission of viral encephalitis to humans, while C. inornata is a suspected vector in the transmission of the disease to animals.

On the basis of larval collections in the study area, over 93 percent of the total mosquito production recorded occurred in waters associated with heavy organic pollution. While this figure corresponds directly with the percentage of sampling stations located in polluted water, it does indicate the willingness of mosquitoes to breed in these waters. Moreover, members of the genera Culex and Culiseta, which comprised over 80 percent of this production, are the primary vectors of viral encephalitis. Such high production of these vector mosquitoes constitutes a definite public health hazard particularly in view of the large resident human population concentrated adjacent to the mosquito-producing area. It is significant to note that 83 percent of the mosquito production occurring in the clean water sampling point was of the genus Aedes. The Aedes mosquito has considerable nuisance impact, but is regarded as having little or no importance as a vector of viral encephalitis.

Light trap collections of adult mosquitoes, as shown in Table II, indicate that A. dorsalis was the predominant species for the months of May and June. From July through the end of the study, C. tarsalis and C. pipiens became dominant with C. pipiens of particular significance in September. It was also noted that C. pipiens were more prominent in the North Denver area than they were at Barr Lake.

Future production of vector mosquitoes in the sewage-laden waters northeast of Denver will remain at a high level so long as the present levels of pollution persist. These vector populations can best be reduced through the abatement or elimination of gross pollution now present in these waters.

TABLE I

Mosquito Larvae Collections

1964 Month	Type of Habitat	No. of Specimens	Aedes dorsalis	Aedes vexans	Culex pipiens	Culex tarsalis	Culiseta inornata
May							
	Borrow Area	45	19	0	0	14	12
	Seepage	38	0	32	0	0	6
	Totals	83	19-23%	32-39%	0	14-17%	18-21%
June							
	Borrow Area	41	4	1	0	34	2
	Reservoir	78	53	2	0	20	3
	Seepage	113	3	25	1	31	53
	Lake Shore	1	0	0	0	1	0
	Marsh	4	0	0	0	4	0
	Fresh Seepage	13	13				
	Totals	250	73-29%	28-11%	1-1%	90-36%	58-23%
July							
	Borrow Area	111	0	0	5	106	0
	Reservoir	76	0	0	0	69	7
	Seepage	143	0	0	0	110	33
	Marsh	19	4	2	0	13	0
	Lake Shore	40	0	0	0	40	0
	Fresh Seepage	38	29	0	0	9	0
	Totals	427	33- 8%	2-<1%	5-1%	347-81%	40- 9%
August							
	Borrow Area	74	0	0	4	70	0
	Reservoir	35	0	7	0	28	0
	Seepage	50	0	0	0	30	20
	Lake Shore	12	0	0	0	12	0
	Fresh Seepage	11	11	0	0	0	0
	Totals	182	11- 6%	7- 4%	4-2%	140-77%	20-11%
September							
	Borrow Area	51	0	0	24	26	1
	Totals	51	0	0	24-47%	26-51%	1- 2%
	Grand Totals	993	136-14%	69- 7%	34-3%	617-62%	137-14%

TABLE II

Mosquito Light Trap Collections

1964 Month	Type of Habitat	No. of Specimens	Aedes dorsalis	Aedes nigromaculis	Aedes vexans	Culex pipiens	Culex tarsalis	Culiseta inornata
May								
	Barr Lake	11	5	0	0	0	2	4
	Denver	0						
	Totals	11	5-45%	0	0	0	2-18%	4-37%
June								
	Barr Lake	16	5	0	0	0	6	5
	Denver	3	2	0	1	0	0	0
	Totals	19	7-37%	0	1-5%	0	6-32%	5-26%
July								
	Barr Lake	385	2	0	7	9	346	21
	Denver	53	1	2	2	31	15	2
	Totals	438	3-<1%	2-<1%	9- 2%	40-9%	361-83%	23- 5%
August								
	Barr Lake	264	6	0	61	38	153	6
	Denver	164	2	0	4	141	17	0
	Totals	428	8- 2%	0	65-15%	179-42%	170-40%	6- 1%
September (One collection)								
	Barr Lake	11	2	0	4	1	4	0
	Denver	23	0	0	0	21	2	0
	Totals	34	2- 5%	0	4-12%	22-65%	6-18%	0
Grand Totals		930	25- 2%	2-<1%	79- 8%	241-26%	545-59%	38- 4%

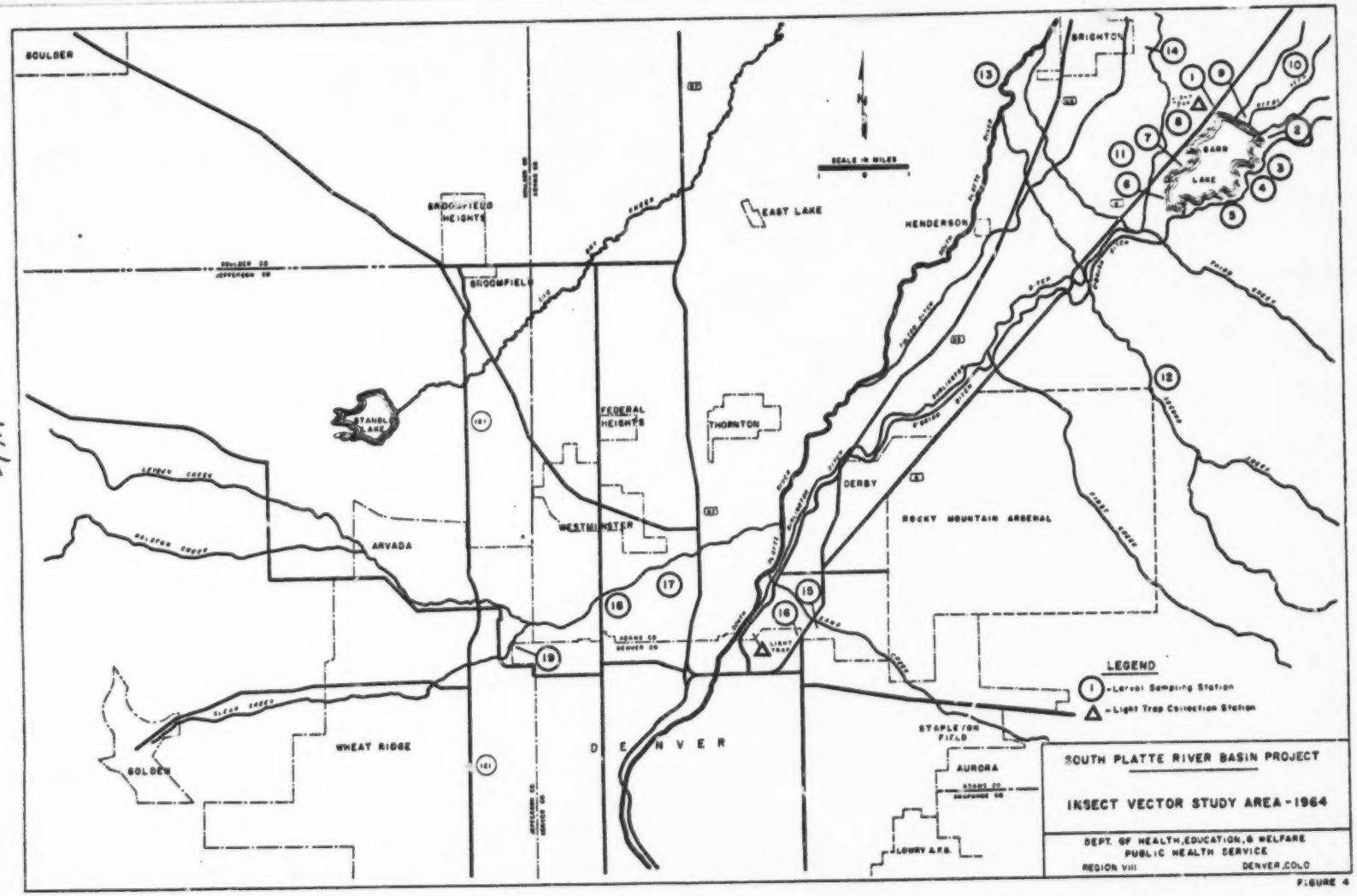
BOULDER
BROOMFIELD HEIGHTS
BROOMFIELD
EAST LAKE
HENDERSON
BRIGHTON
STANDLEY LAKE
FEDERAL HEIGHTS
THORNTON
DERBY
ROCKY MOUNTAIN ARSENAL
ARVADA
WESTMINSTER
WHEAT RIDGE
GOLDEN
DENVER
AURORA
STAPLETON FIELD
LOWRY A.F.B.
SCALE IN MILES
LEGEND
1 = Larval Sampling Station
= Light Trap Collection Station
SOUTH PLATTE RIVER BASIN PROJECT
INSECT VECTOR STUDY AREA - 1964
DEPT. OF HEALTH, EDUCATION, & WELFARE
PUBLIC HEALTH SERVICE
REGION VIII
DENVER, COLO

FIGURE 4

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Observations of Rat Populations in the Denver Area

On April 2, 1964, in conjunction with the Denver City and County Health Department, a survey was made to ascertain the extent of the rat problem in Denver, particularly along the waterways.

The area along the South Platte River from 46th Avenue north to the city limits has long been the focus of serious rat infestation in Denver. As a result of a plague scare in 1963, the Denver City and County Health Department conducted an extensive cleanup campaign along the South Platte River in this area. Using county prisoner help, the river banks were cleared of the trash and dense brush which previously had given the rats excellent cover and protection. In conjunction with this program, an extensive poison bait campaign was waged and still goes on today. The results have been very rewarding. Where there were once literally thousands of rats thriving along this section of the river, there now remains but a trace of the former population. Unfortunately, just across the city line in Adams County the stream and banks remain in poor condition, as shown by Figure 5, and continue to support a thriving rat population.

The survey included a visual inspection of the cleared area. With the brush and trash now gone it could be seen that the banks were literally honeycombed with old rat burrows and runways. One area in particular presented a very desirable habitat for the rats. About 300 yards upstream from the point where the main trunk sewer to the Denver Northside Treatment Plant crosses the South Platte River, there is an outfall from a storm sewer draining the Denver Union Stockyard area. At this point a delta composed of feed corn washed from the stockyards has developed in the South Platte River with an accumulation of corn on the order of six feet deep. This excellent food supply for the rats, along with the good shoreline harborage once made this area extremely attractive for the rats, and still supports a reduced rat population. These conditions are illustrated by Figures 6 and 7.

The problem upstream from the Denver Northside Plant is further compounded by the juncture with the South Platte of many storm sewers draining downtown Denver. When dry, these sewers offer excellent paths of migration for the rats into the heart of the city. Another possible path for the rats would be progressive migration from the stockyard area through the rail yards into the fruit and vegetable wholesale houses and finally into the city proper.

Observations were made downstream from the Denver Northside Sewage Treatment Plant at the junction of York Street and the South Platte River. In this area the river banks are choked with brush and debris providing ideal harborage for the rats. The stream at this point was loaded with scum, offal, and other floating organic matter, providing an excellent food supply for the rats. In essence, the rats

have only to come and take their meal from the river. The poor situation is further compounded at this location by a diversion dam across the river. The river is obstructed by a jumbled mass of rock, broken concrete and debris protruding above the water as shown in Figure 8. Not only does this dam offer excellent rat harborage, but it acts as a huge strainer which traps and retains organic solids floating in the river, thus providing a ready food supply for the rats. Rats were actually observed here scurrying about in broad daylight.

More rat infestation was observed in south Adams County in the vicinity of Clear Creek and Federal Boulevard, where the City of Denver operates a modified sanitary landfill dump. One face of the dump fronts along Clear Creek, affording excellent harborage for rats, as shown in Figure 9. The stream also contains a considerable amount of organic pollution from sewage and industrial wastes, offering a ready food supply to the rats. Additionally, the marshy area surrounding the dump appears to be an excellent mosquito breeding ground. These waters are likely polluted with seepage from the dump and would offer an attractive environment for the breeding of C. tarsalis and C. pipiens in particular.

A privately owned dump, shown in Figure 10, was observed along Sand Creek in the vicinity of the Jorgensen hog farms. Wastes from the hog farms, including an occasional dead hog, are dumped here, affording a good food supply for rats.

The rat problem along the upper reaches of Cherry Creek has never been of great importance, probably because upper reaches of this stream are normally dry. Below the Denver Country Club, where ground water recharge and surface drains contribute significant flow to the stream, rats begin to appear. Illegal waste connections to the surface drains in this area are known to exist. Many rats have been observed by Project personnel near the confluence of Cherry Creek and the South Platte River on various occasions.

Future rat populations along the streams in the above areas will remain at or above their present levels as long as the present pollutional levels and harborage conditions exist. These rat populations can best be reduced through the elimination of the present sewage and industrial waste discharges to the streams and through the elimination of those conditions along the stream banks which provide good harborage for the rats.

Figure 5: South Platte River and Burlington Ditch Diversion at Denver-Adams County line. Notice well-cleared banks in Denver, but heavy brush and trash along the banks in Adams County providing good rat harborage.

Figure 6: Delta of feed corn washed into the South Platte River by drain from Denver Union Stockyards. Just upstream (300 yards) from Denver Northside Sewage Treatment Plant.

GPO 847-223

Figure 7: Rat burrows along east bank of South Platte River in vicinity of corn washings from Denver Union Stockyards.

Figure 8: Excellent rat harborage in jumbled rock across South Platte River near York Street bridge in Adams County.

Figure 9: Denver City dump facing along Clear Creek just east of Federal Boulevard.

Figure 10: Dump along Sand Creek in back of Jorgensen hog farms just east of Dahlia Street. Excellent rat harborage.

FIELD STUDIES: 1944-1962

The following reports taken from the files at CDC, Greeley, are presented here in summary form as a supplement to the foregoing presentation. While many of these reports have furnished the foundation for the previous discussions on rats and mosquitoes, not all of them have direct bearing on the situations of today. They do, however, provide insight into the history and nature of the vector problems within the South Platte River Basin.

"Report on the Fly and Rat Problem in North Denver and Adams County Areas during 1952" (8)

Recognizing that a serious fly problem existed in the northern Metropolitan Denver area, several health agencies conducted a general survey to study the problem in 1952. Three hog farms and two fertilizer plants were checked periodically from May through September. These studies indicated the most serious problem was the breeding of flies in the paunch manure piles at the fertilizer plants, with the hog farms being of somewhat secondary importance. Little or no breeding took place in hog manures, but there was extensive breeding in the garbage being spread out to the hogs for feeding.

In conjunction with the above studies, an extensive rodent control study was also conducted through the summer of 1952. Observations were concentrated in the Washington Street-Platte River area and extending about one mile north beyond the Denver city limits into Adams County. General rat infestation was found throughout the area in association with feedlots, packinghouses, stockyards, dumps, fertilizer plants, manufacturing companies, retail outlets, truck farms, and others. It was also noted that the heaviest infestation was observed along the South Platte River and the Burlington Ditch. The report states that:

> "As would be expected, heavy infestation was observed along the Platte River and Burlington Ditch, where both waterways provide nesting sites and where gross pollution supplies the rat population with food needs. These watercourses are also used by the rats for paths of migration."

"A Reconnaissance of Domestic Rodent Control and Related Environmental Sanitation Problems at Sterling, Colorado" (9)

Domestic rodents had constituted a problem in and around the city of Sterling for a number of years and in 1959 the Northeast Colorado District Health Department requested assistance from the U. S. Public Health Service in evaluating the problem. An initial reconnaissance

was made in June 1959 and a full review of the area was made in November 1959. Light infestation was generally found within the city, while medium to heavy infestation was found in the rural areas adjoining the city. The problems involved poor refuse storage and premise sanitation which provided both food supply and harborage for rats.

"A Preliminary Evaluation of the Fly and Mosquito Problems in the Brush-Fort Morgan Areas of Colorado - June 27, 1957" (10)

On June 27, 1957, representatives of CDC, Greeley, and the Washington and Morgan County Health Departments made a spot survey of the fly and mosquito problem in the Brush-Fort Morgan areas. These two communities are located in the South Platte River Valley about sixty miles east of Greeley, Colorado. The fly problem was associated with poor sanitation practices. The most extensive breeding occurred at the various feedlots in accumulated manure. The sewage effluent from Brush collected in pools on a flat area adjacent to the South Platte River. Numerous rat-tailed maggots were observed in the effluent pools and the adult Syrphid flies were common. However, these flies appear to have little public health significance.

A spot survey was made of mosquito breeding habitats within the town of Brush, in the irrigated areas around Brush, at the Brush sewage outlet, and in the South Platte River bottom area near Fort Morgan and Brush. The primary location of mosquito breeding was observed to be the polluted seepage and flood water pools throughout the river bottom area. Mosquito larvae were collected from several locations, and were subsequently identified. Several species of Culex and Aedes mosquitoes were observed both in the larval and adult stages. The most prevalent mosquito was C. tarsalis, the primary vector of encephalitis in the Basin area. It was expected that heavy Culex breeding would be found in the pools of effluent below the Brush sewage outfall, but this was not the case, probably due to a recent "flushing" of the area by high water. The report states that:

> "The pools of effluent appeared to be ideal breeding sites for Culex pipiens and possibly C. tarsalis where the contents were more dilute."

"Mosquito Survey - Longmont, Colorado, June 21, 1961" (11)

The significant waters included in this survey were the St. Vrain Creek, which flows just south of Longmont; Calkins Lake, which is to the east of Longmont; and several swampy areas to the south of the city lying just north of St. Vrain Creek and adjacent to the Burlington railroad tracks. While both Aedes and Culex mosquitoes were found, those of greatest significance were C. tarsalis, which is a vector

of encephalitis. C. tarsalis was found to breed heavily in the Calkins Lake area, particularly along the fringe in pools somewhat isolated from the main lake by heavy vegetation. C. tarsalis was also found to breed in considerable numbers just north of St. Vrain Creek in the vicinity of the Longmont plant of the Great Western Sugar Company. The most significant breeding area of C. tarsalis was found just southeast of the city, well within the flight range of the mosquito. The waters in this area were contaminated by refuse disposal and had a strong odor of sewage.

"Rodent Survey of Denver, Colorado, October-November, 1944" (12)

In 1944, infestation was found in all parts of Denver with the greatest density by far in the section along the South Platte River from West 46th Avenue to the Burlington Ditch. Several meat packing and feedlot operations which furnish a great deal of food for the rats are located in this area. Animal waste, blood, and tissue were deposited in the river to become a floating menu for the rat population harbored along the banks in the shelter of the brush and riprap. The report states that:

> "The dumping of offal or putrescible wastes into the South Platte River is prohibited by city ordinance, yet enforcement of this law is lax or is not practiced. Edible matter floating down this river supports a considerable number of rats, and the proper treatment of this industrial waste is imperative."

The report further states:

> "The conditions in the northern part of the city, along the South Platte, with its riprap banks and collections of rats in the packing house district, are most favorable to an extension of plague into the wholesale and other metropolitan areas if the disease appears on the north border of the city."

"Report of a Survey of Rodent Problems at Boulder and Longmont, Boulder County, Colorado, February 15, 1961" (13)

The rat problems in these cities arise largely from poor sanitation practices, particularly in the storage of refuse and garbage and the disposal of same. Further problems arise from poor practices in and around livestock feedlots, grain storage, and hog farms. Evidence of rats was observed along the stream which flows through the south part of the Boulder business district. Extensive harborage for rats was present in the form of weeds, tree roots, riprap, and piles of lumber. A food supply in the form of improperly-stored garbage was available along the banks.

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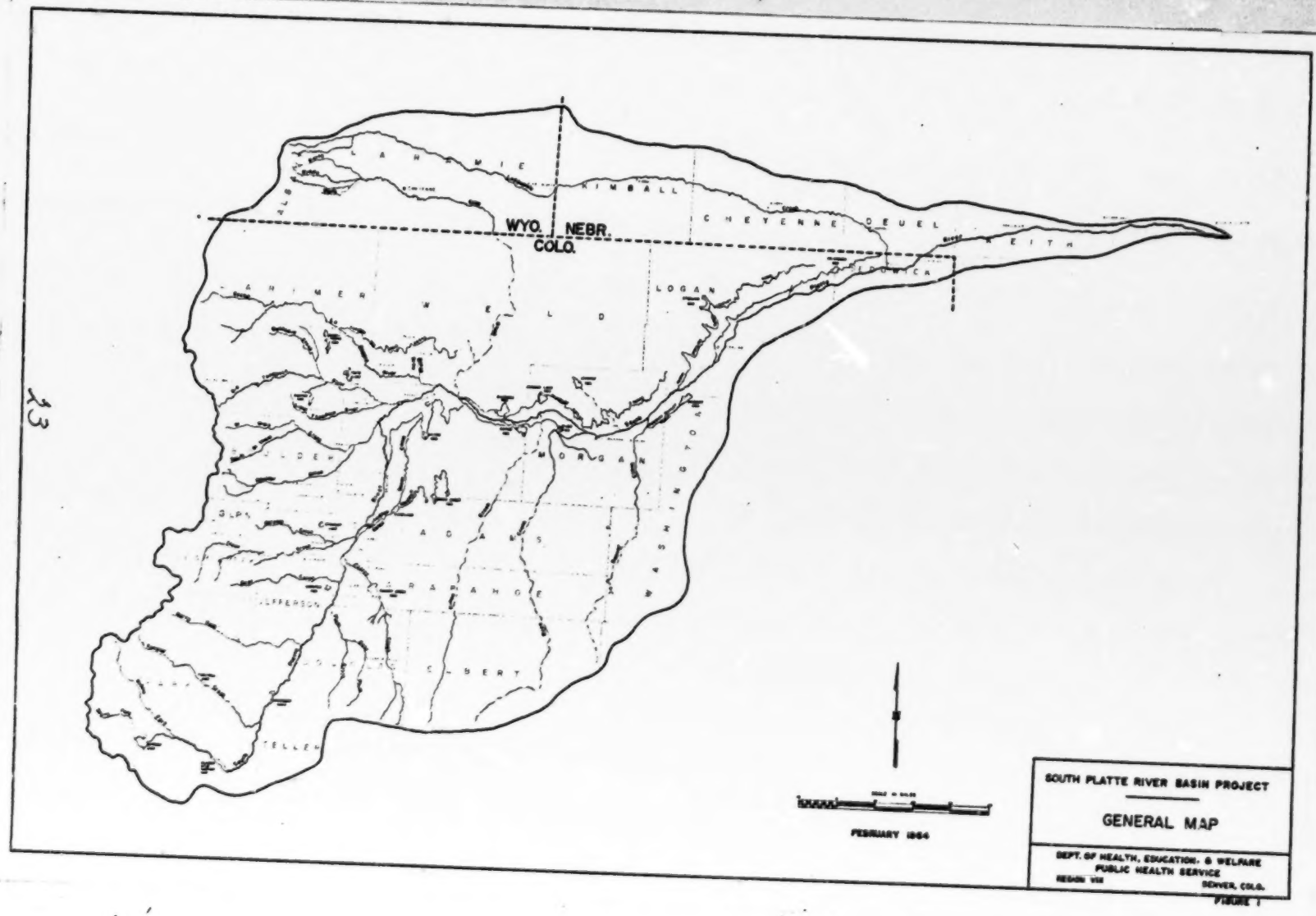
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PHILLIPS
SEDGWICK
LINCOLN
ELBERT
JEFFERSON
DENVER
GILPIN
TELLER
FEBRUARY 1964
SOUTH PLATTE RIVER BASIN PROJECT
GENERAL MAP
DEPT. OF HEALTH, EDUCATION, & WELFARE
PUBLIC HEALTH SERVICE
REGION VIII
DENVER, COLO.
FIGURE 1